UCRL-JC-127866 abs

Modeling Groundwater Flow Through Heterogeneous Porous Media on Massively Parallel Computers

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This presentation describes a sophisticated simulation code for modeling flow and multicomponent transport through three-dimensional heterogeneous porous media. The simulator includes scalable subsurface modeling capabilities, a fast flow solver, and accurate component transport schemes. We employ grid-independent conceptual models and use geostatistical techniques to represent fine-scale heterogeneities. Single-phase fluid flow velocities are calculated via a scalable and fast multigrid algorithm, and advective transport is handled with a high-order Godunov method. Furthermore, we are developing a two-phase air/water flow simulator modeled with a Richards' equation approximation and solved by an inexact Newton method with preconditioned GMRES, as well as a novel temporal subcycling scheme for advection which reduces computational cost and numerical diffusion.

The simulator runs on a variety of computing platforms, from PC's to massively parallel computers. We will show a video highlighting features of the code and real-world sites in two application areas: groundwater remediation and water resource management. These site simulations require up to 8M computational zones, have complex geometries and boundary conditions, varying degrees of subsurface heterogeneity, and numerous pumping wells. We will also demonstrate the scalability of the simulator.

This work was performed under the auspices of the U.S. Dept. of Energy at LLNL under contract no. W-7405-Eng-48.

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